

# State of California

## Office of the State Chief Information Officer

### Infrastructure Consolidation Program

#### Server, Virtualization, Backup and Storage Workgroup

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*Microsoft Hyper-V Virtualization Practices*



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## Document Purpose

This document is intended to provide basic information and recommended practices for the Microsoft server virtualization products including Hyper-V and System Center Virtual Machine Manager. This document identifies and highlights recommended practices only. It is not intended to be a substitute for thorough research and adequate training by State staff working with Microsoft server virtualization products.

## Microsoft Server Virtualization Overview

The Microsoft server virtualization suite consists of Hyper-V, the enterprise bare metal hypervisor and System Center Virtual Machine Manager (or SCVMM), the enterprise server virtualization management product. SCVMM will be explained in the Management Tools section of this document.

Hyper-V runs between the server hardware layer and the operating system layer allowing multiple instances of a supported OS to run unmodified on a single physical server. Hyper-V is a feature available in the Standard, Enterprise and Datacenter editions of Windows Server 2008 and Windows Server 2008 R2. Hyper-V is also available in a standalone product edition called Windows Hyper-V Server 2008 and Windows Hyper-V Server 2008 R2.

The edition of Hyper-V selected will determine the functionality available in the product as well as the inherent virtualization licensing rights granted, if any, with the product. The Standard edition of Windows Server 2008 includes the right to run one instance of the OS in either a virtual or a physical installation. The Enterprise edition license includes the right to 4 instances of the OS in a virtual operating system environment plus one on the physical server. The Datacenter edition includes the right to run an unlimited number of instances of the OS in a virtual operating system environment. The Hyper-V Server 2008 products have most of the functionality of the Enterprise and Datacenter editions but lack a GUI interface and have no included guest virtualization licensing rights.

## Workgroup Recommendations

Each Department or State government entity should select the most cost effective edition of Hyper-V best suited to their needs and environment. Generally, when deploying more than 12 VM's per 2 socket systems the Datacenter edition is the most cost effective. When deploying a pure virtual desktop (VDI) solution or a pure test lab solution, the standalone Hyper-V Server 2008 products can be a good choice. The workgroup recommends the Microsoft Windows Server Virtualization Calculators and the table listed below be used as guidance in determining the correct edition and the correct number of editions to use. The calculator can be found here

<http://www.microsoft.com/Windowsserver2008/en/us/hyperv-calculators.aspx>.

The following table showcases specific scenarios where each Windows Server 2008 edition should be used and where Hyper-V Server 2008 edition should be used:

Virtualization Needs		Microsoft Hyper-V Server 2008 R2	Windows Server 2008 R2 Standard	Windows Server 2008 R2 Enterprise	Windows Server 2008 R2 Datacenter
Scenarios	Server Consolidation	✓	✓	✓	✓
	Test and Development	✓	✓	✓	✓
	Branch Server Consolidation	✓	✓	✓	✓
	Virtual Desktop Infrastructure (VDI)	✓		✓	✓
	Mixed OS virtualization (Linux and Windows)	✓	✓	✓	✓
	Dynamic Data Center			✓	✓
Features	Host Clustering	✓		✓	✓
	Live Migration	✓		✓	✓
	Large Memory support (Host OS) > 32GB	✓		✓	✓
	Support for >4 Processors (Host OS)	✓		✓	✓
	Local Graphical User Interface		✓	✓	✓
	Ability to Add Additional Server Roles		✓	✓	✓
	Guest Virtualization Rights Included in Host Server License		✓	✓	✓
	Application Failover			✓	✓

Source: <http://www.microsoft.com/hyper-v-server/en/us/default.aspx>

## Management Tools

### In The Box Tools

Microsoft Hyper-V ships as a feature of the Windows Server 2008 and Windows Server 2008 R2 server products. As an included feature of the OS, all required tools for full management of Hyper-V are included out-of-the-box. The Hyper-V management console (MMC) is included for full support of all Hyper-V features including Cluster Shared Volumes (CSV). The Windows Failover Cluster management console is included for full support of clustered Hyper-V hosts and highly available (HA) virtual machines. The Windows Server Backup tool is included for full support of host and virtual machine backups.

### System Center Virtual Machine Manager

SCVMM is a solution for managing the entire feature set of Hyper-V in a single tool. SCVMM leverages a GUI interface connecting to PowerShell commands to manage both Hyper-V hosts and guests. In addition to full management of Hyper-V and guests SCVMM provides the following features:

- Physical-to-virtual migration and virtual-to-virtual migration support
- Intelligent virtual machine placement
- Centralized resource optimization
- Ability to concurrently manage the older Microsoft Virtual Server 2005 product
- Support for management of VMware ESX infrastructure
- Rapid provisioning of virtual machines
- Performance and Resource Optimization
- SCVMM Resource Library for templates, support files, and disk images
- Full support for PowerShell

### Workgroup Recommendations

The Workgroup has found that for small or limited deployments of Hyper-V “In the Box” tools may be sufficient although even these deployments tend to mature into environments that can benefit from SCVMM as well as other Microsoft product offerings. The California State Lands Commission, a small State Agency, began using Hyper-V approximately two years ago and is now experienced using both “In the Box” tools and SCVMM. Their experience can be found under “Use Case” below.

## Monitoring

The Windows Server operating system includes several tools for monitoring the health of features and roles installed on the server. The Hyper-V feature is fully supported with these “In the Box” tools. For more advanced and automated monitoring of Hyper-V the SCVMM product includes PRO with System Center Operations Manager (SCOM) integration.

### PRO and SCOM Integration

Performance and Resource Optimization, or PRO, is used to create a dynamic management environment of virtual resources in a Hyper-V and SCVMM deployment. By utilizing SCOM PRO enabled management

packs, SCVMM events can be automated to address situations such as hardware, operating system, or application performance issues or failures. PRO can be enabled to automatically take corrective actions or wait for review and approval by system administrators.

## **Workgroup Recommendations**

Monitoring is a critical part of managing any server environment. The higher density of servers in a server virtualization environment makes monitoring even more critical. The Hyper-V feature can be fully monitored through the standard Windows Server tools such as Performance Monitor and host hardware generally includes hardware monitoring tools provided by the manufacturer. While these tools may be sufficient for small deployments of Hyper-V the Workgroup suggests utilizing SCVMM PRO with SCOM for most environments, large and small.

The resources that you might wish to consider monitoring on an ongoing basis using built-in performance monitoring tools available in all Windows Server 2008 products are presented below under Exhibits.

## **Hyper-V Host Sizing and Configuration**

### **Server Type**

Windows Server 2008 and Hyper-V support any 64-bit (x64) server hardware that is on the Windows Hardware Compatibility list. No special hardware configurations are required other than support for hardware-assisted virtualization (Intel VT or AMD-V) technology. A list of supported hardware can be found here <http://www.windowsservercatalog.com>

### **Commodity Server**

Traditional rack mounted and tower server configurations are generally referred to as commodity servers. These server types include a broad range of configurations from small 1U platforms with 1 or 2 processor sockets and 4 memory slots to large 7U platforms with 8 processor sockets and 64 memory slots. These types of servers have the most configuration choices and can achieve the highest density of virtual machines per server.

### **Blade Server**

A blade server is a compact modular server design that leverages blade enclosure to provide resources such as power, cooling, network and storage connectivity. Common blade enclosures range in size from 6U to 10U and hold from 4 to 16 blade servers. Blade servers come in two sizes known as full height and half height. Blade servers generally have fewer configuration options, are less expandable and achieve lower virtual machine density than the larger commodity type servers. Blades do however, provide reduced power and cooling requirements as well as substantially reduced cabling requirements in a simple to expand modular platform.



## Processor

Hyper-V supports all modern x64 processors from Intel and AMD. These processors generally have from 2 to 8 cores per socket package. These cores are referred to as logical processors. Intel processors may also include a technology known as Hyper-Threading which creates the functionality of additional logical processors for each physical core in the processor socket package. Hyper-V presents virtual processors to a virtual machine and maps these virtual processors back to logical processors through a process known as time slicing. Microsoft supported limit is 8 virtual processors per logical processor. The number of logical processors in a given server will determine the maximum number of possible virtual processors that can be created on that server. As an example, a 4 socket server with 4 logical processors per socket, has been validated and will be supported by Microsoft with up to 128 virtual processors. This is important to consider when sizing server hardware for Hyper-V.

## Memory

Hyper-V assigns memory to virtual machines in an exclusive manor. This means the amount of memory assigned to a virtual machine will be reserved for the assigned virtual machine to the exclusion of other processes or virtual machines. The Hyper-V parent partition generally requires at least 512 MB of RAM available after RAM is assigned to virtual machines as virtual memory. Each virtual machine on a host will create a certain amount of memory overhead for the parent partition. A rule of thumb for parent partition overhead related to virtual machine memory is 32 MB of RAM for each VM with up to 1 gigabyte of virtual memory plus 8 MB of RAM for each additional gigabyte of assigned virtual memory. As an example, if a host has 10 virtual machines each with 2 gigabytes of virtual memory assigned the host would see about 400 MB  $((10 \times 32) + (10 \times 8))$  of overhead.

**(NOTE:** Early reports from Microsoft mention that with the future release of Service Pack 1 for Windows Server 2008 R2 will add Dynamic Memory to the feature set of Hyper-V. Since little is currently known about this no recommendations can be made at this point.)

## Networking

Hyper-V supports two different types of virtual network adapters; emulated network adapters and synthetic network adapters. Synthetic adapters were designed to provide substantially improved network performance with lower processor overhead then emulated adapters can provide. Emulated adapters, while slower, are required for certain scenarios such as PXE boot and when running virtual machines with an unsupported OS. Hyper-V supports multiple network adapters per virtual machine when necessary.

## Storage

As with networking adapters, Hyper-V supports two different types of virtual storage adapters; emulated network adapters and synthetic network adapters. Synthetic storage adapters were designed to provide substantially improved performance with lower processor overhead then emulated adapters can provide. Hyper-V storage adapters can connect to 3 different types of virtual hard disks (VHD's) as well as pass-through disks. Below is a summary of the VHD types from the Microsoft Performance and Tuning Guidelines for Windows Server 2008 R2:

## **Dynamically expanding VHD**

Space for the VHD is allocated on demand. The blocks in the disk start as zeroed blocks but are not backed by any actual space in the file. Reads from such blocks return a block of zeros. When a block is first written to, the virtualization stack must allocate space within the VHD file for the block and then update the metadata. This increases the number of necessary disk I/Os for the write and increases CPU usage. Reads and writes to existing blocks incur both disk access and CPU overhead when looking up the blocks' mapping in the metadata.

## **Fixed-size VHD**

Space for the VHD is first allocated when the VHD file is created. This type of VHD is less apt to fragment, which reduces the I/O throughput when a single I/O is split into multiple I/Os. It has the lowest CPU overhead of the three VHD types because reads and writes do not need to look up the mapping of the block. Fixed-sized VHDs can easily be resized (larger) as additional drive capacity is required. Fixed-size VHDs can be decreased in size though substantially more effort is required to do so.

## **Differencing VHD**

The VHD points to a parent VHD file. Any writes to blocks never written to before result in space being allocated in the VHD file, as with a dynamically expanding VHD. Reads are serviced from the VHD file if the block has been written to. Otherwise, they are serviced from the parent VHD file. In both cases, the metadata is read to determine the mapping of the block. Reads and writes to this VHD can consume more CPU and result in more I/Os than a fixed-sized VHD.

For a deep analysis of VHD performance see the document here:

[http://download.microsoft.com/download/0/7/7/0778C0BB-5281-4390-92CD-EC138A18F2F9/WS08\\_R2\\_VHD\\_Performance\\_WhitePaper.docx](http://download.microsoft.com/download/0/7/7/0778C0BB-5281-4390-92CD-EC138A18F2F9/WS08_R2_VHD_Performance_WhitePaper.docx)

## **Pass-through Disk**

Hyper-V also supports pass-through disks, where the virtual hard disk maps directly to physical storage without encapsulation in a VHD file. This type of storage can reduce CPU overhead and increase I/O to the storage system. Pass-through disks also allow for virtual hard drives of more than 2 TB which is the maximum size limit of a VHD file.

## **Physical Storage Option**

### **Direct Attached Storage**

Direct attached storage is utilized in all cases save those where boot from SAN is leveraged. Even in the event that the primary data store is located on shared storage the parent partition will generally reside on direct attached storage, though the amount of storage will often be only large enough to support the parent.

In many cases ranging from branch office server builds to budgetary considerations and the technical strength of IT staff, it is often desirable and highly functional to use direct attached storage in your virtual operations.

In circumstances when high availability is not required or possible, or where it is prohibited by the virtual workload, the direct attached storage configuration may be drastically expanded to accommodate storage needs.

Some examples of workloads that would prohibit Hyper-V high-availability configuration, thereby necessitating the use of direct attached storage include:

- Network load balanced web servers,
- SQL database mirroring
- Any Microsoft Failover Cluster workload
- Exchange 2007 CCR (Continuous Cluster Replication)
- Exchange 2010 DAG (Database Availability Groups)
- Software with licensing which may prohibit frequent server relocation (as in Live Migration or Quick Migration)

## Shared Storage

Widely considered a best-practice in all virtual environments, shared storage is required in order to take advantage of Hypervisor high availability, dynamic resource allocation (PRO Tips), and Live/Quick migration.

Many shared storage solutions also provide advanced tools that allow for SAN-based backups and offsite replication of data thus providing for additional backup and operational recovery options.

Modern shared storage solutions are available in many configurations consisting of low cost SATA disks, common 10k rpm disks, SAS disks, and extremely fast, high I/O fiber channel disks. Connectivity options include 1/10 gig iSCSI, 4/8 gig fiber channel and 10 gig fiber channel over Ethernet. These varying configurations provide an opportunity to map storage to the appropriate workload. Slow SATA drives may be appropriately used for low I/O virtual machines while faster 15k SAS or Fiber channel drives should be used for virtual machines requiring higher I/Os such as database servers.

## Workgroup Recommendations

In many cases the cost per VM is very similar in commodity servers and blade servers. Each department should evaluate their particular needs when deciding what server type to use for Hyper-V however the Workgroup makes the following general recommendations, many of which are discussed in more detail later in this document:

### Server Types

- Modular design requirements, power and cooling reduction goals, white floor size and design, and cabling requirements are should be considered when deciding between blades and commodity servers for Hyper-V deployments.

- Select blade servers when your department requires lower overall power, cooling, cabling and rack space requirements and you have the white floor design to support increased power and heat density.
- Select Blade servers when you require high CPU density but can work with lower I/O density.
- Select large commodity servers when you are looking to maximize the number of virtual machines per physical server.

## Processors

- Do not exceed 8 virtual processors per logical processor
- Select processors with at least 4 cores
- Choose more processors cores over higher clocked processors when budgets constrains your options
- Utilize Hyper-threading when using Intel processors
- Understand the workloads that will be run on Hyper-V virtual machines and select processors accordingly.
- Assigning multiple virtual processors to virtual machines can be beneficial to many virtualized workloads but never assign more virtual processors than the virtualized application can consume efficiently. Using a single virtual processor for a VM when appropriate avoids unnecessary loads on the physical host server.
- Do not select more cores then can benefit from the memory capacity of the server; generally a single processor core per 4 gigabytes of RAM sufficient.

## Memory

- Understand the workload requirements of the workloads to be virtualized and assign only the amount of RAM necessary for proper virtual machine performance.
- Account for host memory reserve requirements when calculating how much memory to choose when sizing a host server
- A good rule of thumb when sizing a server for memory is to use at least 4 gigabytes of RAM per physical server core. Solutions that require large amounts of memory may push the configuration to 8 gigabytes or more of RAM per physical server core.
- When possible, select higher density memory chips in order to maximize the amount of available memory per memory slot.
- Use standard performance measurement tools to confirm that you have not committed too much or too little memory to your virtual machines. When in doubt error on the side of over-committing and not under-committing RAM.

## Network

- Use synthetic adapters when possible
- Use emulated adapters when required but replace them with synthetic adapters as soon as possible (such as when PXE is required for deployment)
- Use dedicated physical and virtual network adapters for iSCSI storage presented directly to the virtual machine.

- Use physical network adapters with network offload capabilities
- Leverage network teaming solutions for the server vendor when necessary to provide highly available network adapters or when additional bandwidth is required

## Storage

- Use synthetic storage adapters for optimum performance
- Use fixed size VHD's for optimum performance
- Use a VHD of adequate size for the guest OS. Some example sizes are:
  - 20 gigabytes Windows 2003 Server guest OS
  - At least 30 and up to 40 gigabytes for a Windows Server 2008 guest OS
- Use synthetic SCSI virtual adapters when hot-add virtual machine storage is required or when more than 4 VHD's are required per virtual machine.
- Use pass through disks when SAN tools require it, when near physical disk performance is required or when the target storage LUN presented to the virtual machine exceeds 2 TB.
- Size all storage used by virtual machines the same way you would size the storage for a physical machine.
- Make sure the underlying physical storage solution can meet the combined performance demands of all virtualized workloads that will be placed on the storage device.
- Dynamic and Differencing VHD's can provide a highly efficient platform for building lab and test environments on Hyper-V but should be avoided in most production workloads

## High Availability

Hyper-V supports host high availability through the use of Windows Fail-over Clustering. This is the same fail-over clustering technology used with other Microsoft products like SQL server and Exchange server. No special server hardware requirements are required for Windows fail-over clusters other than shared storage. Any server or component on the Windows Server 2008 or Windows Server 2008 R2 hardware compatibility list is supported in a Hyper-V fail-over cluster. When a node in an HA cluster fails, the virtual machines that had been hosted on that node will be restarted on the most appropriate remaining node. High availability in Hyper-V can leverage, but does not require cluster shared volumes. Cluster shared volumes allow multiple hosts in a cluster to access the same storage volume through the use of file level locks instead of volume level locks. When cluster shared volumes are used, multiple HA virtual machines can be placed on the same LUN and failed-over to another host independently of each other. When cluster shared volumes are not used all virtual machines on a LUN must be owned by the same host and will all fail-over together in the case of a host failure. The Hyper-V Live migration and Quick migration features require that the host servers are part of a fail-over cluster.

## Workgroup Recommendations

- Use fail-over clusters when live migration or quick migration is desired
- Use fail-over clusters for virtual machines that require a high level of resiliency to hardware failure

- Use cluster shared volumes when more than one highly available virtual machine will be placed on the same LUN.
- Enable PRO in SCVMM to further extend the capabilities of virtual environments on fail-over clusters
- Use maintenance mode in Windows Server 2008 R2 Hyper-V to evacuate all VM's off of a host when performing scheduled system maintenance
- Host HA does not protect the guest operating system instance from failure or provide the guest OS with clustering features.
- When the guest OS requires additional availability such as patching without downtime guest clustering should be implemented
- Always use a dedicated virtual adapter mapped to a dedicated physical adapter when configuring guest clustering through iSCSI.
- Never combine host HA with guest HA on the same host. As an example don't place a SQL server guest that is part of a SQL mirror group on a host that is part of a fail-over host cluster without excluding the guest from the host HA functionality.

## Security

Securing host systems and virtual machines are critical considerations when building and maintaining your virtual environment. While both host and virtual servers should generally be secured much as any other physical server some additional steps are advised.

Please refer to the Hyper-V™ Security Guide, Version 1.0, published: March 2009 for an excellent primer on the security of both host and virtual servers. The document can be found at <http://www.microsoft.com/downloads/details.aspx?familyid=2220624B-A562-4E79-AA69-A7B3DFD090&displaylang=en>

## Protecting Host Servers

### Server Core

Microsoft recommends the use of the Windows 2008 Server Core because it reduces:

- servicing requirements
- management requirements
- attack surface
- disk space usage

More details on server core can be found here: [http://msdn.microsoft.com/en-us/library/ee391626\(VS.85\).aspx](http://msdn.microsoft.com/en-us/library/ee391626(VS.85).aspx).

In an environment where there are a sufficient number of highly experienced administrations where highly reliable and highly specialized servers are required the use of Server Core may be appropriate and

should be considered. In smaller organizations or organizations lacking sufficient administrative experience caution should be taken before implement Server Core.

According to Microsoft ([http://msdn.microsoft.com/en-us/library/ee391631\(VS.85\).aspx](http://msdn.microsoft.com/en-us/library/ee391631(VS.85).aspx)), “The minimal nature of Server Core creates limitations”:

- There is no Windows shell and very limited GUI functionality (the Server Core interface is a command prompt).
- There is limited managed code support in Server Core.
- There is limited MSI support (unattended mode only).

What does this mean practically speaking? Most server administrators can comfortably and competently manage servers using a GUI. Unless administrators are comfortable using the command line to manage their servers a steep learning curve may be required to adequately manage servers. The time to recover from driver or system failures may also be protracted when using Server Core.

Those considering the use of Server Core can refer to the Server Core Installation Option Getting Started Guide at [http://technet.microsoft.com/en-us/library/cc753802\(WS.10\).aspx](http://technet.microsoft.com/en-us/library/cc753802(WS.10).aspx)

### Other Host Considerations

- Run only the Hyper-V role on the host server
  - *“The root partition should be dedicated to the virtualization server role. Additional server roles can adversely affect the performance of the virtualization server, especially if they consume significant CPU, memory, or I/O bandwidth. Minimizing the server roles in the root partition has additional benefits such as reducing the attack surface and the frequency of updates. System administrators should consider carefully what software is installed in the root partition because some software can adversely affect the overall performance of the virtualization server.”*  
<http://download.microsoft.com/download/A/2/F/A2F199C0-672E-44E6-BF1D-878E233C3F08/ProvisioningHyper-VVirtualMachineinHostingEnvironment.docx>
- Shut down all unnecessary services
  - This may seem an old saw but this is true today as it has ever been. Unnecessary services consume resources needlessly and increase the server’s attack surface.
- Use the Windows Server® 2008 Security Compliance Management Toolkit (<http://www.microsoft.com/downloads/details.aspx?FamilyID=5534bee1-3cad-4bf0-b92b-a8e545573a3e&displaylang=en>)
  - *The Windows Server 2008 Security Compliance Management Toolkit provides you with an end-to-end solution to help you plan, deploy, and monitor the security baselines of servers running Windows Server® 2008 in your environment.*
- Use discrete NICs for management of host vs. operation of virtual machines (see Networking section for additional details).

- Each Host needs its own firewall, antivirus, and intrusion detection software
- Host machines should be added to the appropriate organizational units (OUs) so that Group Policy settings apply correctly.

## Protecting virtual machines

- Use Offline Virtual Machines Servicing Tool
  - *"...offline machines do not automatically receive operating system, antivirus, or application updates that would keep them compliant with current IT policy. An out-of-date virtual machine may pose a risk to the IT environment. If deployed and started, the out-of-date virtual machine might be vulnerable to attack or could be capable of attacking other network resources.*  
*Therefore, IT groups must take measures to ensure that offline virtual machines remain up-to-date and compliant. At present, these measures involve temporarily bringing the virtual machine online, applying the necessary updates, and then storing it again."*  
<http://technet.microsoft.com/en-us/library/cc501231.aspx>
- Use private or internal network to prevent test virtual machines from accessing other network resources and conversely to prevent other networking resources from accessing test virtual machines (see Networking for details)
- Use BitLocker™ Drive Encryption on the Hyper-V host
  - The use of BitLocker generally produces a small and often indiscernible performance degradation of the host server. However, this is offset by the fact that its use prevents worries and potentially expensive reporting requirements in the event that virtual machines are stolen or improperly accessed. The cost of such reporting, as has been repeatedly reported in the news over the last several years, can be prohibitive, not only as to financial costs but staff time lost to the effort as well.
  - Administrators should properly plan for and test BitLocker implementations before installing and running it in a production environment. Windows BitLocker Drive Encryption Design and Deployment Guides can be downloaded at <http://www.microsoft.com/downloads/details.aspx?familyid=41BA0CF0-57D6-4C38-9743-B7F4DDBE25CD&displaylang=en>
- Limit physical administrative access to Host servers
  - Maintain a clear separation of duties between those administrators who are responsible for the operation of host versus virtual servers. Poor administrative decisions/actions on a virtual server will impact that server. Poor administrative decisions/actions on a host can impact every virtual server running on that host.
  - You can use Authorization Manager (AzMan), a snap-in for the Microsoft® Management Console (MMC), to assign selected users and groups to the Hyper-V Administrator role so they can use Hyper-V Manager without being administrators of the physical computer itself.
- Audit access to all virtual machines



- Virtual machines access should be audited just like physical servers. The use of security auditing and logging, for example, is highly recommended for both physical and virtual servers.
- Delegate virtual machine management (SCVMM2008)
  - The Delegated Administrator profile grants administrative access to a defined set host group(s) and library server(s). Users whom belong to a Delegated Administrator role can use the VMM Administrator Console to modify the configuration of all virtual machines defined on any Hyper-V hosts that they control.
- Leverage Web-based Virtual Machine Manager Self-Service Portal
  - The Self-Service Portal grants administrative access to a defined set of virtual machines through the Web-based Virtual Machine Manager Self-Service Portal.
  - Self-service users cannot use the SCVMM 2008 console to manage virtual machine resources.
  - This practice is consistent with limiting physical and virtual access to physical hosts.

## Workgroup Recommendations

Security is an expensive and often double-edged sword. The amount of time, energy and resources committed to securing your virtual environment will rely on a variety of factors which only you can effectively evaluate. The recommendation of the workgroup, then, is to thoroughly evaluate the circumstances of your organization including the nature (i.e. sensitivity) of the data that your organization generates, domiciles and manages and then implement those practices above most suited to your organization and the resources that it can commit to securing its computing environment.

## Backup and Recovery of Hosts, Virtual Machines and Datasets

While traditional file-level and application specific back-ups of virtual machine content still plays an important role in the management of data, block level backups of the entire Hyper-V server, as are performed by programs like Windows Server Backup, have now become an invaluable operational recovery tool. A common practice, then, is to incorporate both back-up types into your operational schema.

## Traditional File-Level Backups

File level backups are required for certain disk setups. EX Physical disks that are directly attached to a virtual machine and host-level backups of iSCSI volumes in guest VMs can't be backed up using the Hyper-V VSS writer.

The use of commercial back-up software like Symantec's Back-up Exec or Microsoft's Data Protection Manager can and arguably should continue to be used to perform file-level back-ups. This traditional method of backups allows for the rapid recovery of data at the file level and provides for an expanded set of targets for the storage of back-ups not available in Windows Server Backup.

Traditional backups do have their failings in the virtual world, however.

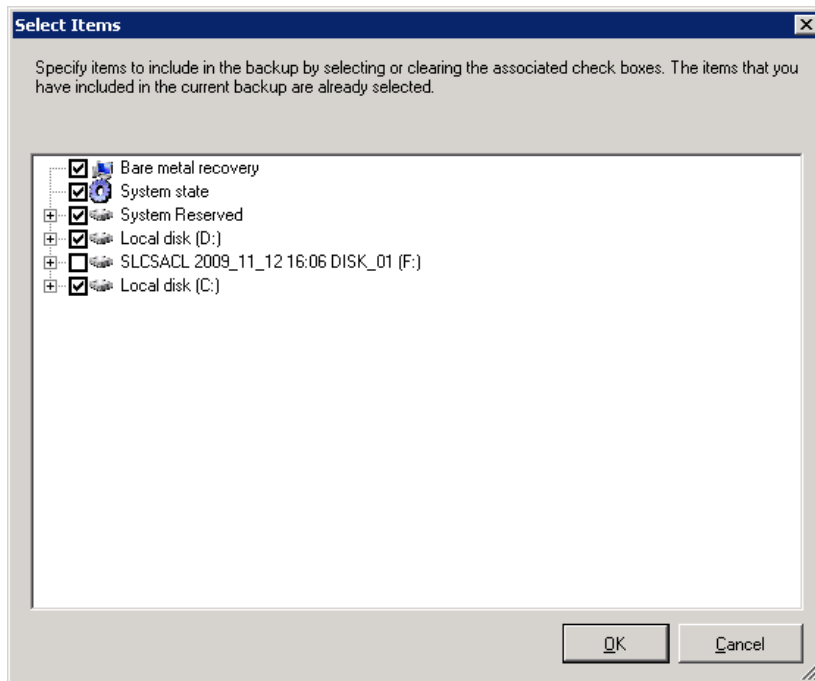
- In the event that you must rebuild/recreate a virtual machine prior to the recovery of files it is imperative that you have documented all VM configuration information to facilitate the rebuild process. Obviously configuration details of virtual machines cannot be restored if they aren't being backed-up.
- Restores can be done at a more granular level but are also more cumbersome. Instead of restoring the entire Hyper-Visor, including the volumes on which virtual machines and their configurations reside, you must first rebuild the virtual machine and then properly configure the operating system. In the case of a file server, for example, numerous file shares may need to be created before data can be restored. This process can be both time consuming and tedious and creates the opportunity for human error.
- This approach generally requires the installation of back-up software agents on each virtual machine.

### Block-Level Backups

Windows Server Backup is a feature built into all versions of Server 2008 including Server 2008R2. This simple, free backup solution allows you to easily and inexpensively schedule the back-up of the entire host server. Other commercial back-up software that supports VSS Writer can perform the same function but as a rule such software is neither simple nor free.

This type of back-up can be configured to back-up the entire drive system of the host server to facilitate bare-metal recoveries in the event of a catastrophic server failure.

In the example below you can see that “Bare metal recovery”, “System state”, “System Reserved”, and both local disks were selected for back-up.



In the event of a catastrophic server failure one would simply need to attach the external hard drive to which backups were created to the new server, start the server, choose Recover Windows, and the entire contents of the first host can be quickly installed on the new host. The time from server failure to complete recovery can be measured in minutes. ***Note that the new server should be substantially similar in architecture to the server it is replacing.***

Like traditional backups this back-up type has its shortcomings as well:

- The number of backup targets is limited and include:
  - File shares (only complete backups will be performed, each time overwriting your previous backups (in other words no differential backups possible)
  - Optical Media or Removable Media
  - Internal Hard Disk
  - External hard disk
- If off-site storage of data is a concern multiple external hard disks can be used as part of the back-up schema. This process may become cumbersome and would involve shipping physical hard disks for storage at off-site locations with all of the incumbent concerns with doing so.
- There are other functional considerations including: Be aware that virtual machines that contain dynamic disks cannot be backed up by WSB. Virtual machines that do not include support for VSS backups—such as Windows 2000, Windows XP, or virtual machines that do not have Integration Components installed—cannot be backed up using WSB. Lastly, be cautious

with the use of snapshots, as virtual machines that contain two or more snapshots will fail to restore. <http://technet.microsoft.com/en-us/magazine/2009.06.geekofalltrades.aspx>

### **Remember!**

No matter what your backup method is. It is imperative to test your backups by performing restores. Backup and restoration methodologies and practices should be well-documented and tested.

## **Guest Sizing and Configuration**

Many of the administrative and performance guidelines that apply to physical servers also apply to virtual servers. However, administrators must consider additional factors when managing virtual servers.

### **Basic Configuration**

The following items apply to virtual machines of all types and purposes:

- Install and use Integration Components on all supported operating systems
  - Integrations components (ICs) are sets of drivers and services that help your Virtual Machines have more consistent state and perform better by enabling the guest to use synthetic devices.
- A good rule of thumb for virtual machine performance overhead on the host is 110% to 125% of assigned resources. As an example:
  - 16 GB of RAM assigned to virtual machines would be equal to 20 GB of RAM utilization on the host (16 x 1.25)
- Avoid running roles, features or services that are not required by the virtual machine OS to perform its required functions
- Use Server Core for Windows Server 2008 virtual machine operating systems when possible
- For stability and performance use 64-bit guest operating systems when possible
- Apply consistent server naming conventions
  - SCOM will complain if the NetBIOS name of your virtual server is different from the VM name you have assigned that virtual server in SCVMM2008.
- Use proper OS type when building VMs (Standard, Enterprise, Datacenter)
- When possible, use Synthetic Network Adapters, not Emulated (legacy) Network Adapters.
  - This is not always possible as addressed in the Networking section of this document. Synthetic adapters will provide for greater throughput and should be used when possible.
- Virtual Server drives should be sized to the specific needs of the server and organization
  - There is no hard and fast rule regarding the proper size of a virtual hard drive for the System volume or for any other volume on your virtual servers.
  - Oversized hard drives needlessly waste valuable storage space. Undersized hard drives can impair performance.

- Remember, though, that undersized hard drives can easily be resized. It is far more complex and time consuming to reduce the size of a virtual drive and requires the use of third party products like Partition Magic.
- It is recommended that applications and databases be installed on separate partitions.
- Understand and configure automatic power on options.

## Guest Virtual Processors

Each virtual processor creates an overhead for the host. Always configure the virtual machine with the correct number of virtual processors for the workload and avoid arbitrarily creating multi-processor virtual machines if a single processor would suffice.

## Guest Memory

Guests should be provided the amount of memory required by the services they provide.

As a general rule start by assigning your guests 2 gigs of RAM but you should be prepared to increase or decrease this amount based on your observations about performance.

- Monitor RAM usage patterns. Standard monitoring tools go a long way to determining whether appropriate RAM has been committed.
  - Create a data collector set in Server 2008 that monitors critical performance data like RAM activity. Collect the data for a reasonable period of time to help determine the sufficiency of RAM committed to the guest.
- Rely on your personal observations and the observations of your constituency.
- Use pass through disks when optimum virtual machine performance is required, when the virtual machine requires more the 2 TB of storage on a single volume, or when you want to leverage native SAN business continuity tools that are not compatible with virtual disks.
- With synthetic adapters there is no disk performance difference between virtual IDE and virtual SCSI attached disks
- Use synthetic SCSI adapters to support hot add of virtual machine virtual hard disks
- Always use dedicated synthetic network adapters to support iSCSI initiators in a virtual machine.

## Networking

Networking in Hyper-V is thoroughly addressed in the document *Understanding Networking with Hyper-V* available at:

<http://www.microsoft.com/downloads/details.aspx?displaylang=en&FamilyID=3fac6d40-d6b5-4658-bc54-62b925ed7eea>

While much of this section has been excerpted from that document a number of principals are worth addressing here.

## 4 Networking Types

There are 4 types of networking available in Hyper-V; private, internal, external and Dedicated External Virtual Network. Each type is described and circumstances under which you might use each has been provided.

- Private: Virtual machines connected to this type of network can communicate among themselves. The management OS has no direct network connectivity with the virtual machines.
  - This networking type allows administrators/developers to create a completely isolated environment for testing and development purposes. No threats to the host server or internal network(s) exist because this networking type creates no communication channels between the virtual machines and the host/internal network(s).
- Internal: Virtual machines connected to this type of network can communicate among themselves and the management OS. There is no connectivity with the physical network.
  - Two interesting uses for an Internal network include:
    - You might want to isolate a virtual machine from your domain network to test a Dynamic Host Configuration Protocol (DHCP) server or a domain controller. Because the virtual machine is isolated, you cannot move files from the virtualization server to the virtual machine by using the domain network. To overcome this limitation, you can use an internal virtual network. [http://technet.microsoft.com/en-us/library/ee256061\(WS.10\).aspx](http://technet.microsoft.com/en-us/library/ee256061(WS.10).aspx)
    - Since you cannot directly bind Hyper-V machines to the 802.11 wireless network connection you can create an internal network and share the wireless connection with your virtual machines. <http://bryantlikes.com/SettingUpHyperVVirtualNetworking.aspx>
- External: An external virtual network binds to miniports which may exist in the form of multiple miniports for a single physical NIC, a single miniport representing multiple physical NICs, or a single miniport representing a single physical NIC, allowing both virtual machines and the management OS to access the physical network.
  - In English – create an external network when you want your virtual servers to be able to fully interact with other network resources.
- Modified External: The dedicated virtual network is a modified form of the external virtual network offered by Hyper-V. This type of virtual network allows VMs to communicate with other VMs on the same machine, as well as with VMs on other systems. They can also access the external network, although these VMs do not have direct access to the management OS as in the external virtual network configuration. Removing this direct path eliminates many of the drawbacks of the external virtual network type.

- If two internal or private virtual networks are created in Hyper-V and two virtual machines are created on a separate IP subnet, they cannot communicate with each other. The virtual switch operates at layer 2 of the ISO/OSI Network Model. To achieve routing at higher levels, a router needs to be used the same as would be done in a physical environment. ISA 2006 or RRAS may be used to achieve this functionality.

## General Best Practices

- Have at least two physical NICs. If additional services are required, add additional physical network adapters as needed.
  - Use a dedicated NIC for the Hyper-V parent partition.
- Develop and use standard/consistent network adapter naming conventions
- Each virtual machine can have a total of 12 virtual network adapters. Eight network adapters can be assigned to a high-speed synthetic adapter and four network adapters can be assigned to a legacy adapter.
- Whenever possible, use high-speed devices in the virtual machines by enabling the integration services.

## Advanced Options

- Use NIC teaming if the added redundancy fault tolerance is required for the application. NIC teaming must be supported by the NIC vendor.
  - NIC teaming is the process of grouping together several physical NICs into one single logical NIC, which can be used for network fault tolerance and transmit load balance. The process of grouping NICs is called teaming. Teaming has two purposes:
  - Fault Tolerance: By teaming more than one physical NIC to a logical NIC, high availability is maximized. Even if one NIC fails, the network connection does not cease and continues to operate on other NICs.
  - Load Balancing: Balancing the network traffic load on a server can enhance the functionality of the server and the network. Load balancing within network interconnect controller (NIC) teams enables distributing traffic amongst the members of a NIC team so that traffic is routed among all available paths.
    - <http://www.howtonetworking.com/networking/nicteam1.htm>
- Large Send Offload (LSO) and Checksum Offload (CSO). Ensure that LSO and CSO are enabled where they are supported.
  - Large Send Offload (IPv4) and Large Send Offload (IPv6) enable the adapter to offload the task of segmenting TCP messages into valid Ethernet frames. Because the adapter hardware is able to complete data segmentation much faster than operating system software, this feature may improve transmission performance. In addition, the adapter uses fewer CPU resources.
    - <http://www.intel.com/support/network/adapters/pro100/sb/CS-029402.htm#lso>

- TCP Checksum Offload (IPv4) and TCP Checksum Offload (IPv6) enable the adapter to compute (Tx) or verify (Rx) the TCP checksum of packets. TCP Checksum Offload is configured under TCP/IP Offloading Options properties when Intel® PROSet for Windows Device Manager is installed. This feature may improve performance and reduce CPU utilization. With Offloading enabled, the adapter computes or verifies the checksum for the operating system.
  - <http://www.intel.com/support/network/adapter/pro100/sb/CS-029402.htm#tco>
- Use Jumbo Frames for NICS configured to use iSCSI communications.
  - In computer networking, jumbo frames is a feature that allows Ethernet hardware to send, receive, or transport Ethernet frames above 1518 bytes in size. The most common deployments of jumbo frames have an MTU of 9000 bytes.
  - Not all networking equipment supports Jumbo Frames so proceed with care when considering the use of Jumbo Frames
- Enable TCP chimney if it is supported by the NIC manufacturer.
  - TCP Chimney Offload is a networking technology that helps transfer the workload from the CPU to a network adapter during network data transfer. In Windows Server 2008, TCP Chimney Offload enables the Windows networking subsystem to offload the processing of a TCP/IP connection to a network adapter that includes special support for TCP/IP offload processing.
    - <http://support.microsoft.com/kb/951037>
- Enable Virtual Machine Queuing if it is supported by the NIC manufacturer.
  - Virtual Machine Device Queues (VMDq) is a silicon-level technology that offloads network I/O management burden from the hypervisor. Multiple queues and sorting intelligence in the silicon support enhanced network traffic flow in the virtual environment, freeing processor cycles for application work.
    - <http://software.intel.com/file/1919>
- Network binding order should be sequenced as follows:
  - The adapter used for managing the Hyper-V parent partition
  - The adapters used for iSCSI, Live Migration and Clustered Shared Volume communications
  - The private network used for cluster heartbeat
  - All the adapters associated with virtual networks



## Exhibits

### Performance Monitoring

<b>Overall health</b> <ul style="list-style-type: none"><li>• Hyper-V Virtual Machine Health Summary</li><li>• Hyper-V Hypervisor</li></ul>	<b>Hyper-V Virtual IDE Controller</b> <ul style="list-style-type: none"><li>• Read Bytes / Sec</li><li>• Write Bytes / Sec</li><li>• Read Sectors / Sec</li><li>• Write Sectors / Sec</li></ul>	<b>Memory</b> <ul style="list-style-type: none"><li>• Available Bytes</li><li>• Pages /Sec</li><li>• Hyper-V Hypervisor Partition</li><li>• Hyper-V Root Partition</li><li>• Hyper-V VM Vid Partition</li></ul>
<b>Storage</b> <ul style="list-style-type: none"><li>• Physical Disk</li><li>• Hyper-V Virtual Storage Device<ul style="list-style-type: none"><li>○ Error Count</li><li>○ Flush Count</li><li>○ Read Bytes / Sec</li><li>○ Write Bytes / Sec</li><li>○ Read Count</li><li>○ Write Count</li></ul></li></ul>	<b>Processor</b> <ul style="list-style-type: none"><li>• Processor</li><li>• Hyper-V Hypervisor Logical Processor<ul style="list-style-type: none"><li>○ %Guest Run</li><li>○ %Hypervisor Run Time</li><li>○ %Idle Run Time</li><li>○ %Total Run Time</li><li>○ Hyper-V Hypervisor Root Virtual Processor</li><li>○ Hyper-V Hypervisor Virtual Processor</li></ul></li></ul>	<b>Networking</b> <ul style="list-style-type: none"><li>• Network Interface<ul style="list-style-type: none"><li>○ Bytes Total / Sec</li><li>○ Offloaded Connections</li><li>○ Packets / Sec</li><li>○ Packets Outbound Errors</li><li>○ Packets Receive Errors</li></ul></li><li>• Hyper-V Virtual Switch<ul style="list-style-type: none"><li>○ Bytes/Sec</li><li>○ Packets/Sec</li></ul></li><li>• Hyper-V Legacy Network Adapter<ul style="list-style-type: none"><li>○ Bytes Dropped</li><li>○ Bytes Sent / Sec</li><li>○ Bytes Received / Sec</li></ul></li><li>• Hyper-V Virtual Network Adapter<ul style="list-style-type: none"><li>○ Bytes / Sec</li><li>○ Packets / Sec</li></ul></li></ul>

## Use Case

### Virtualization and the California State Lands Commission (CSLC)

The process of virtualizing servers can seem a daunting task. With dwindling IT staffing levels and what seems to be a never ending stream of demands from our users the idea of wholesale changes to a traditional approach to servers and server management can appear overwhelming. This need not be the case, however.

We have shared the experiences of the CSLC to illustrate that a slow and measured approach to virtualization and the implementation of tools supporting virtualization need not cause too many nights of lost sleep and that even small organizations can reap substantial benefits from deploying other tools designed to support and facilitate the administration of the virtual environment.

### Background

The CSLC began virtualizing its server environment approximately two and 1/2 years ago. This was shortly after Microsoft released Hyper-V. In addition to Hyper-V we evaluated several competing products and concluded, based on several factors, that Hyper-V was the best choice for use. Those factors included cost, ease of use, cost of training, cost of maintenance and our ability to identify and hire consultants when system support was required.

Our decision to enter the virtualization world was not predicated on political mandate but rather on many of the now traditional factors currently driving virtualization efforts; the under-utilization of hardware resources, the need to control hardware expense, IT staffing levels and competencies and the desire to reduce the organization's carbon footprint.

Our sometimes slow adoption of other technologies supporting virtual operations, many of which are describe below, was the direct result of circumstances known well by every IT staff member in the State and included competing workloads, a lack of staff with skills and experiences needed to support the products, and not because of a lack of desire on the part of the organization.

### Tools and Timelines

#### Hyper-V MMC Snap-In

For something on the order of 12-15 months we relied exclusively on the MMC to manage all virtual machines. With 4 hypervisors located in three offices in northern and southern California this required us to remote into a physical server to use the MMC to manage local virtual servers. This was the exclusive means by which all virtual servers were managed for more than a year. While not a perfect solution or one promoted or suggested by Microsoft it was practical given our circumstances and served our needs nicely.

#### System Center Virtual Machine Manager (SCVMM)

Shortly after becoming aware of SCVMM we downloaded and installed the product, still in Beta, and began using it almost daily.

In our case we made very limited use of the product. The program was used to create and configure virtual servers and as a means, although an incomplete one, of quickly determining the health of our virtual servers, and for little more.

In the last 4 months the way we use the product has changed rather significantly. We are now preparing to install the SCVMM 2008R2 administrative console on administrator workstations and to limit administrative access to virtual servers exclusively through the product. This will allow us to make effective use of the administrative roles native to the product including the delegated administration role and the self-service role (discussed elsewhere in this exhibit). The exclusive use of SCVMM to access and manage virtual machines, coupled with the use of native roles, will allow us to create a more secure environment as we will no longer be forced to rely on Remote Desktop to access and administer virtual servers. The use of roles native to SCVMM will allow us to even further restrict administrative access to specific Host Groups.

We have also begun using the product to migrate virtual machines between host servers. As our experiences with virtualization have grown and our needs changed, we found the simplicity of migration offered in the product highly useful and convenient. This process is far easier and more convenient than was our traditional approach which involved copying and pasting VHD files from one server to the next and then creating new virtual machines.

#### System Center Operations Manager (SCOM)

At the same time our view and use of SCVMM began to change, or perhaps because of it, we installed and have begun using System Center Operations Manager (SCOM). This tool has allowed us greater insight into the health of our networking operations and paid handsome dividends to us within 24 hours of deployment. We were immediately made aware of network latency and disk IOP issues, issues to that point in time we of which we were unaware. SCOM has also provided us early warning about disk utilization as well as the degradation of disk performance due to fragmentation. It also brought to our attention problems we were suffering with our Active Directory structure and provided us the information necessary to take immediate corrective actions.

As part of our effort to deploy SCOM we also performed the suggested SCOM/SCVMM integration. This was a seamless effort and has provided all users of SCVMM ready access to critical performance measures of all physical hosts and virtual servers. The information provided has helped us tune our virtual servers to maximize hardware resources. In some cases we had over-committed resources, particularly memory. In other cases resources had been under-committed. Without the ready reporting made available by the integration we would not have been able to so readily identify issues and take the necessary corrective actions.

#### Self-Service Portal

We have recently built a self-service portal for use by our administrators. Even in a small shop with so few administrators, or perhaps because of it, I was spending far too much time creating virtual servers for development and production purposes. While the actual time to stand up new servers was measured in minutes I was still required to adjust an already overburdened work calendar in order to

accommodate the requests for new servers. Once the deployment of the self-service portal has been completed I will be freed of the tedium and demands on my time as I am no longer required to stand up new virtual servers. The use of the self-service portal will also allow us the opportunity to limit the ability of our administrators to build a limited number of servers based on templates and hardware profiles that are secure and consistent with internal requirements.

### *Windows Server Backup*

Because of prior issues arising from our backup efforts we have become sensitive, perhaps overly sensitive, to ensuring that we have reliable backups of our servers, both physical and virtual. With the release of Server 2008 Backup as a standard feature on the operating system we are comfortable that we have solid and reliable backups at our disposal.

Until such time that we are able to purchase SANs for placement in our two principal offices, and until we have sufficient bandwidth to support site-to-site replication of data, we have come to rely on attached USB drives as targets for backups of our Hypervisors. We still perform file level backups as well but the use of Windows Server Backup has proven to be an invaluable addition to our backup strategies.

### *Next Steps*

#### *Data Protection Manager (DPM)*

As is the case with many organizations server/data backups have always proven problematic. Although we are currently using a commercial software package to manage and conduct backups issues with the product have arisen. In particular, there has often been a predictable lag between the release of new products like Server 2008R2 and the ability of our backup software to actually backup such releases. At the moment none of our R2 servers are being backed up by our current backup software. This has resulted from a combination of the time lag in the backup software vendor's release of an agent that supports R2 and our internal ability to install, test and deploy the new agents.

We believe that our next logical step is to investigate the functionality of Data Protection Manager. We not only expect that this product will meet our immediate and future backup needs but we anticipate that it may alleviate long standing issues with our current back-up software.

#### *SAN Storage*

It has become clear to the organization that the most prudent and desirable next step is the purchase and deployment of an iSCSI SAN coupled with the deployment of a cluster server pair. This physical architecture will not only provide the organization and its staff consistent and guaranteed access to critical networking resources but will also alleviate many of the challenges the organization has faced for years vis-à-vis the creation of current, dependable backups as well as the ability to perform necessary restores from these back-ups.

#### *Live Migration*

Beyond addressing long-standing backup issues and providing a highly available environment for our uses we are looking forward to using Live Migration.

As a server administrator there is nothing more frustrating than knowing that every reboot of a physical host is going to take multiple virtual servers off-line, even if only for a few minutes as the host server is rebooted. The only effective way to mitigate the impact on users is to work or require my IT staff to work after hours every time simple administrative tasks like patching is performed.

The ability to rapidly migrate a virtual server from one host to another, so that administrative tasks can be performed on that server with no noticeable impact to our staff is something that we have aspired to for years. The fact that our overworked system administrators will no longer be required to work odd hours to manage their servers would also be welcome.

### **The bottom line**

By using Hyper-V we were able to take a slow and measured approach to virtualizing our environment while containing costs. The product has proven highly stable, affordable, and easy to maintain. More important to us are the facts that the product is well laid-out and highly intuitive to use. We did not have the staff or resources to suffer a long and steep learning curve and with Hyper-V we didn't need to.

We have also been able to deploy and use products in support of our virtualization as time and financial resources have allowed.

Erich Cress  
California State Lands Commission

## References

Performance Tuning Guidelines for Windows Server 2008

[http://www.microsoft.com/whdc/system/sysperf/Perf\\_tun\\_srv.mspx](http://www.microsoft.com/whdc/system/sysperf/Perf_tun_srv.mspx)

Performance Tuning Guidelines for Windows Server 2008 R2

[http://www.microsoft.com/whdc/system/sysperf/Perf\\_tun\\_srv-R2.mspx](http://www.microsoft.com/whdc/system/sysperf/Perf_tun_srv-R2.mspx)

Microsoft Virtualization Calculators

<http://www.microsoft.com/Windowsserver2008/en/us/hyperv-calculators.aspx>

Hyper-V TechNet Library

[http://technet.microsoft.com/en-us/library/cc753637\(WS.10\).aspx](http://technet.microsoft.com/en-us/library/cc753637(WS.10).aspx)

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<http://technet.microsoft.com/en-us/library/bb740737.aspx>

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<http://www.microsoft.com/virtualization/en/us/products-server.aspx>

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<http://www.microsoft.com/hyper-v-server/en/us/default.aspx>

Microsoft VHD Performance Analysis

[http://download.microsoft.com/download/0/7/7/0778C0BB-5281-4390-92CD-EC138A18F2F9/WS08\\_R2\\_VHD\\_Performance\\_WhitePaper.docx](http://download.microsoft.com/download/0/7/7/0778C0BB-5281-4390-92CD-EC138A18F2F9/WS08_R2_VHD_Performance_WhitePaper.docx)